Computational Linguistics: Crash Course on Prolog

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Contents

1. Introduction

Today we will look at how to use PROLOG to store information, namely to store a knowledge base of facts and how to ask queries.

2. Knowledge Base

```
wizard(harry).
wizard(ron).
wizard(hermione).
muggle(uncle_vernon).
muggle(aunt_petunia).
chases(crookshanks, scabbars).
```

Given this KB, you can ask for instance the following queries

```
?- wizard(harry).
yes
?- muggle(harry).
no
?- witch(hermione).
ERROR: Undefined procedure: witch/1

?- chases(X,Y).
X = crookshanks
```

```
Y = scabbars ;
no
?- chases(X,X).
no
```

3. A bit of syntax: atoms and variables

Atoms

- All terms that consist of letters, numbers, and the underscore and start with a **non-capital letter** are atoms: `harry`, `uncle_vernon`, `ritaSkeeter`, `nimbus200` ...
- All terms that are enclosed in single quotes are atoms: 'Professor Dumbledore', '(@ *+ ', ...
- Certain special symbols are also atoms: `+`, `,` , ...

Variables

- All terms that consist of letters, numbers, and the underscore and start with a **capital letter** or an underscore are variables: `X`, `Hermione`, `_ron` ...
- _ is an anonymous variable: two occurrences of _ are different variables.

4. A bit of syntax: complex terms

Complex terms

- Complex terms are of the form: $functor(argument, ..., argument)$.
- Functors have to be atoms.
- Arguments can be any kind of Prolog term, e.g., complex terms. `likes(ron,hermio` `likes(harry,X)` but also `f(a,b,g(h(a)),c)`, ...

5. Facts and Queries

Facts Facts are complex terms which are followed by a full stop.

```
wizard(hermione).
muggle(uncle vernon).
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```

Queries Queries are also complex terms which are followed by a full stop.

? - `wizard(hermione).`

where, ? - is the prompt provided by the Prolog Interpreter and `wizard(hermione).` is the query.

6. kb2: a knowledge base of facts and rules

```
eating(dudley).
happy(aunt_petunia) :- happy(dudley).
happy(uncle_vernon) :- happy(dudley), unhappy(harry).
happy(dudley) :- kicking(dudley,harry).
happy(dudley) :- eating(dudley).
```

where,

- `:-` stands for "if ... then ...": If `happy(dudley)` is true, then `happy(aunt petunia)` is true.

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where,

- `:-` stands for "if ... then ...": If `happy(dudley)` is true, then `happy(aunt petunia)` is true.
- `,` stands for "and": If `happy(dudley)` is true and `unhappy(harry)` is true, then `happy(uncle vernon)` is true.

6. kb2: a knowledge base of facts and rules

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where,

- :- stands for "if ... then ...": If `happy(dudley)` is true, then `happy(aunt petunia)` is true.
- , stands for "and": If `happy(dudley)` is true and `unhappy(harry)` is true, then `happy(uncle vernon)` is true.
- "or" is expressed by the last two facts. If `kicking(dudley,harry)` is true or if `eating(dudley)` is true, then `happy(dudley)` is true.

7. Queries to kb2

```
eating(dudley).
happy(aunt_petunia) :- happy(dudley).
happy(uncle_vernon) :- happy(dudley), unhappy(harry).
happy(dudley) :- kicking(dudley,harry).
happy(dudley) :- eating(dudley).
```

Some possible queries to kb2

```
?- happy(dudley).
yes
?- happy(aunt_petunia).
yes
?- happy(uncle_vernon).
no
?- happy(X).
X = aunt_petunia ;
X = dudley ;
no
```

8. A bit of syntax: Rules

Rules are of the form `Head :- Body.`

- Like facts and queries, they have to be followed by a full stop.
- Head is a complex term.
- Body is complex term or a sequence of complex terms separated by commas.

```
happy(aunt_petunia) :- happy(dudley).
happy(uncle_vernon) :- happy(dudley),
                       unhappy(harry).
```

9. Kb3: facts and rules containing variables

Let's take a knowledge base that defines 3 predicates: father/2, mother/2, and wizard/1.

```
father(albert,james).
father(james,harry).
mother(ruth,james).
mother(lili,harry).
wizard(lili).
wizard(ruth).
wizard(albert).

wizard(X) :- father(Y,X),
             wizard(Y),
             mother(Z,X),
             wizard(Z).
```

10. Rules

```
wizard(X) :- father(Y,X),
             wizard(Y),
             mother(Z,X),
             wizard(Z).
```

The rule says:

> For all X, Y, Z, if `father(Y,X)` is true and `wizard(Y)` is true and `mother(Z,X)` is true and `wizard(Z)` is true, then `wizard(X)` is true. I.e., for all X, if X's father and mother are wizards, then X is a wizard.

11. Queries to kb3

```
father(albert,james).
father(james,harry).
mother(ruth,james).
mother(lili,harry).
wizard(lili).
wizard(ruth).
wizard(albert).

wizard(X) :- father(Y,X),
             wizard(Y),
             mother(Z,X),
             wizard(Z).
```

Some possible queries to kb3

```
?- wizard(james).
yes
```

```
?- wizard(harry).
yes
?- wizard(X).
X = lili ;
X = ruth ;
X = albert ;
X = james ;
X = harry ;
no
?- wizard(X), mother(Y,X), wizard(Y).
X = james
Y = ruth ;
X = harry
Y = lili ;
no
```

12. Ancestors

Given the KB below, we want to define a predicate `grandparent_of(X,Y)` which is true if X is a grandparent of Y.

```
parent_of(paul,petunia).
parent_of(helen,petunia).
parent_of(paul,lili).
parent_of(helen,lili).
parent_of(albert,james).
parent_of(ruth,james).
parent_of(petunia,dudley).
parent_of(vernon,dudley).
parent_of(lili,harry).
parent_of(james,harry).
```

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```
parent_of(paul,petunia).
parent_of(helen,petunia).
parent_of(paul,lili).
parent_of(helen,lili).
parent_of(albert,james).
parent_of(ruth,james).
parent_of(petunia,dudley).
parent_of(vernon,dudley).
parent_of(lili,harry).
parent_of(james,harry).
```

```
grandparent_of(X,Y) :- parent_of(X,Z), parent_of(Z,Y).
```

13. Ancestors

Similarly,

```
greatgrandparent_of(X,Y) :- parent_of(X,Z),
                            parent_of(Z,A),
                            parent_of(A,Y).
greatgreatgrandparent_of(X,Y) :- parent_of(X,Z),
                                 parent_of(Z,A),
                                 parent_of(A,B),
                                 parent_of(B,Y).
```

13. Ancestors

Similarly,

```
greatgrandparent_of(X,Y) :- parent_of(X,Z),
                            parent_of(Z,A),
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greatgreatgrandparent_of(X,Y) :- parent_of(X,Z),
                                 parent_of(Z,A),
                                 parent_of(A,B),
                                 parent_of(B,Y).
```

This doesn't work for "ancestor of"; don't know 'how many parents we have to go back'.

14. Ancestor

```
ancestor_of(X,Y) :- parent_of(X,Y).
```

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```
ancestor_of(X,Y) :- parent_of(X,Z), ancestor_of(Z,Y).
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```
ancestor_of(X,Y) :- parent_of(X,Z), ancestor_of(Z,Y).
```

The presence of the same predicate in the head and the body of the rule indicates we have a **recursion**.

15. Lists

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[Head|Tail] is a list if
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In Prolog: a special kind of data structure, i.e., special kinds of Prolog terms.

```
[] The empty list
[Head|Tail] is a list if
Head is a term (atom, variable, complex term) and Tail is a list.
```

For instance,

```
[a,b,c] A list with elements a, b and c
[a|Tail] A list with the element a and the elements in the Tail
```

you can also find eg. `[a,b | [c,d]]` for the list `[a, b, c, d]`.

16. Concatenation

`concatenate/3`: a predicate for concatenating two lists. `concatenate(X,Y,Z)` should be true if Z is the concatenation of X and Y; for example, concatenating [a] with [b,c] yields [a,b,c].

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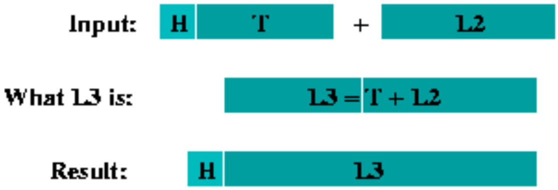
This predicate `concatenate(X,Y,Z)` is defined following the ideas below:

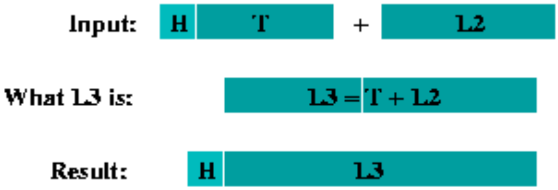
- if X is [], then Z=Y is the concatenation of X and Y.
- if X is the list `[H|T]` then `[H|T1]` is the concatenation of X and Y if T1 is the concatenation of T and Y.

Formally,

```
concatenate([],L,L).
concatenate([Head|Tail],L,[Head|NewTail]) :-
             concatenate(Tail,L,NewTail).
```

Remark, "append" is an alternative way of calling the predicate "concatenate".


Input:
H
T
+
L2
What L3 is:
L3 = T + L2
Result:
H
L3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17. Split List

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```
?- append(X,Y,[a,b,c]).
X = []
Y = [a,b,c] ;

X = [a]
Y = [b,c] ;

X = [a,b]
Y = [c] ;

X = [a,b,c]
Y = [] ;

no
```

18. Conclusion

Now have fun using Prolog!!